Program Assignment 2, EE5352

In this program assignment, you will calculate the ensemble autocorrelation function for colored Gaussian noise and its power spectral density. You will also plot both functions. Assume that colored Gaussian noise $x(n)$ is generated as $x(n) = h(n)*e(n)$, where $e(n)$ is white Gaussian noise with a variance of 1.

1. Write a function called `Imp(\omega, N_h, h, n_d)` which generates a linear-phase lowpass filter impulse response as

$$h(n) = \frac{\sin(\omega (n-n_d))}{\pi(n-n_d)} , n_d = \frac{1+N_h}{2}$$

for $1 \leq n \leq N_h$, given a user-chosen cut-off frequency $\omega$, and a filter length $N_h$.

2. Write a function `Mag(h, N_h, Amp, w, N)` which uses function DFT to generate the amplitude response of the filter $h(n)$ as

DFT($h$, $N_h$, $N$)
For $1 \leq k \leq N/2$
Amp($k$) = |$H(k)$|
w($k$) = $(2\pi/N)(k-1)$
End

3. Write a function called `FEA(h, N_h, v, N_v)` which generates the right side of the finite energy autocorrelation as

For $0 \leq m \leq N_h - 1$
v(1+m)=0
For $1 \leq n \leq N_h - m$
v(1+m) = v(1+m)+h(n)h(n+m)
End n
End m
N_v = N_h

4. Write a function called `PSD(v, N_v, N_h, P, w, N_vv)` which generates the PSD as

$vv(N_v) = v(1)$
For $1 \leq k \leq N_h - 1$
$vv(N_v-k) = v(1+k)$
$vv(N_v+k) = v(1+k)$
End k
N_vv = 2*N_h - 1
DFT($vv$, $N_vv$, $N_vv$, $H$)
For $1 \leq k \leq N/2$
P($k$) = |$H(k)$|
w($k$) = $(2\pi/N)(k-1)$
End
5. After the function are working,
   (a) Using IMP (perhaps more than once) with Nh = 63 to generate h(n) for a bandpass filter having cut-off frequencies with \( w_1 = .6 \) and \( w_2 = 1.2 \). Plot h(n) versus n.
   (b) Use function Mag to find the magnitude response Amp(k) of h(n). Plot Amp(k) versus w(k) for \( 0 \leq w(k) \leq \pi \).
   (c) Use function FEA to find the finite energy autocorrelation v(m) of h(n). Plot v(m).
   (d) Use function PSD to generate the PSD P(k) of x(n), using v(m). Plot P(k) versus w(k) for \( 0 \leq w(k) \leq \pi \).

Pseudocode for function DFT is as follows:

```
DFT(h, Nh, N,H)
Dw = (2\pi)/N
WN = exp(-j\cdot Dw)
WW = 1./WN
For 1 \leq k \leq N
  w(k) = (2\pi/N)(k-1)
  H(k) = 0.
  WW = WW\cdot WN
  W3 = 1./WW
  For 1 \leq n \leq Nh
    W3 = W3\cdot WW
    H(k) = H(k) + h(n)\cdot W3
  End n
End k
```